

Int. F. of Arch. Sci. - 1984



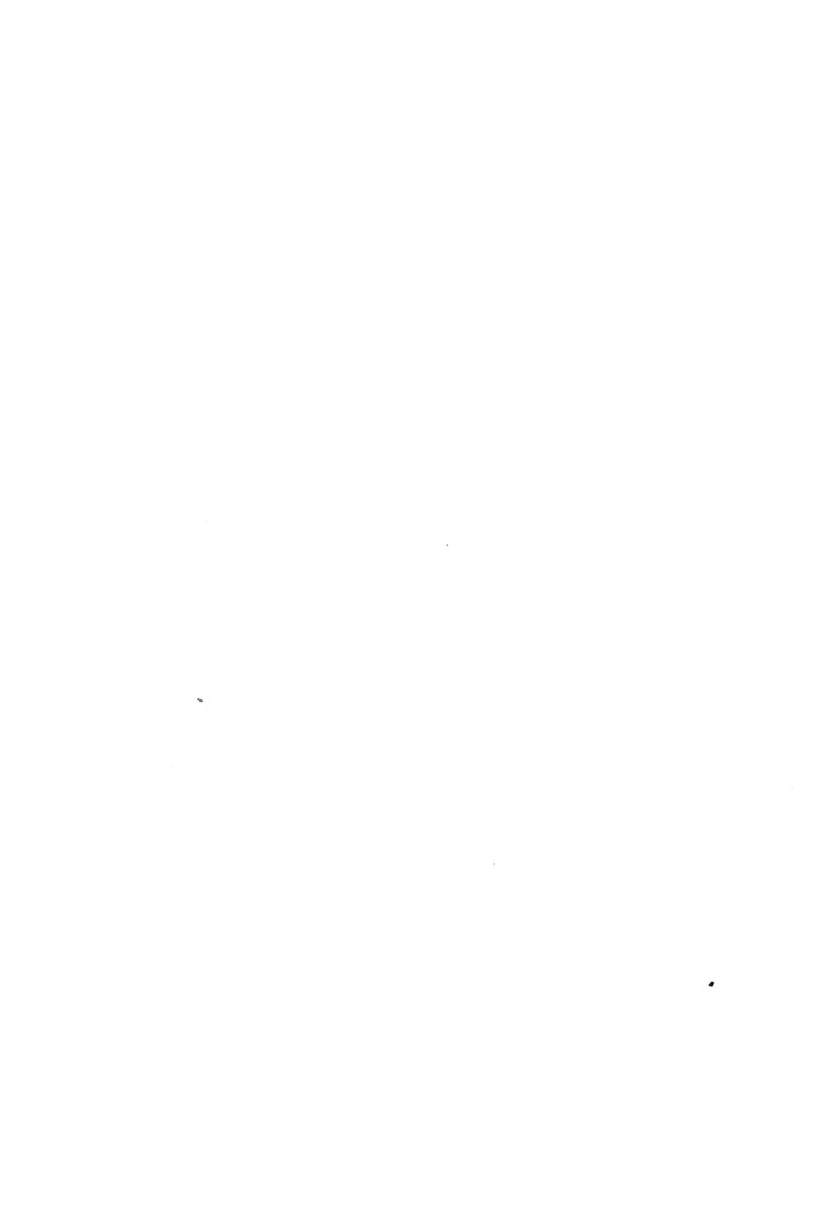
3 1151 02722 6350

FACE

THE IMPROVEMENT OF SPEED AND ACCURACY IN TYPEWRITING

by

Roy Edward Hoke.



THE IMPROVEMENT OF SPEED AND ACCURACY IN TYPEWRITING
=====

A dissertation submitted to the Board of
University Studies of the Johns Hopkins University
in conformity with the requirements for the degree
of Doctor of Philosophy.

by

Roy Edward Hoke.

Baltimore, 1921.

THE IMPROVEMENT OF SPEED AND ACCURACY IN TYPEWRITING

TABLE OF CONTENTS

INTRODUCTION.

- I. THE FREQUENCY OF THE OCCURRENCE OF LETTERS AND
MARKS IN THE ENGLISH LANGUAGE.
- II. ERRORS IN TYPEWRITING AND THEIR CAUSES.
- III. RELATIVE ABILITIES OF THE RIGHT FINGERS AND
THE TWO HANDS FOR TYPEWRITING.
- IV. THE FINGER AND HAND LOADS OF OUR PRESENT
TYPEWRITER KEYBOARD.
- V. THE CONSIDERATIONS TO BE TAKEN INTO ACCOUNT IN
THE ARRANGEMENT OF AN IDEAL KEYBOARD
BASED ON SCIENTIFIC PRINCIPLES AND A
SUGGESTION FOR SUCH KEYBOARD.

BIBLIOGRAPHY.

VITA.

THE IMPROVEMENT OF SPEED AND ACCURACY IN TYPEWRITING

Some time ago the writer began work on the problem of constructing standard tests in typewriting, such as have been and are being formulated for the various subjects of the elementary and secondary school curricula. The first preliminary investigations, however, revealed the fact that there were other typewriting problems which might logically claim priority. First, since typewriting is a matter entirely of the use of the letters of the alphabet and the various marks, it seemed necessary to investigate the frequency of the occurrence of these letters and marks in the English language. Secondly, since accuracy is one of the primary requisites of good typewriting, it appeared to be important to investigate the number and distribution of errors made in actual typewriting, and to learn, if possible, their causes. Third, the modern "touch" method of typewriting presumably makes equal demands upon all the fingers and upon the two hands. In fact, the typewriter keyboard is so arranged as to assign fifteen letters to the left hand, and only eleven to the right. The problem arises: what are the relative abilities of the eight fingers and the two hands. Fourth, the determination of the loads or burdens of work

which the present typewriter keyboard places upon the fingers and hands. Fifth, an attempt to enumerate the considerations which must be taken into account in the arrangement of a scientific keyboard; a suggested keyboard, and the criticism of the same from the considerations set forth.

The field of this investigation is one that has not been cultivated. With the exception of the work by Book on "The Psychology of Skill", little or no experimentation has been done in typewriting. Even in Book's study, the object was not so much the improvement of speed, accuracy or methods of teaching typewriting, as it was the more general aim of ascertaining, by the use of the typewriter as a mere bit of apparatus, the psychology of skill. Any other mechanism, an adding machine or piano for instance, would have been equally capable of use in a study of skill, though perhaps not equally convenient for experimental purposes.

I. THE FREQUENCY OF THE OCCURRENCE OF LETTERS AND MARKS IN THE ENGLISH LANGUAGE.

The first objective of our problem is to determine the frequency with which the various letters of the alphabet and the more common marks are used in the English language. For this purpose valuable material was readily at hand in the form of the Ayres Spelling Scale. This scale itself informs us that the 1000 words in the list are "the product of combining different studies with the object of identifying the 1000 commonest words in English writing." The scale was formed by combining four different vocabulary studies as follows:

- (1) A study by Ayres himself involving a total of 23,629 words found in personal and business letters.
- (2) The study of Eldridge comprising 43,989 words found on two pages each of four different newspapers.
- (3) The study of Rev. Knowles of London, of the vocabulary of the English Bible and various authors, to a total of 100,000 words.
- (4) The study of Cook and O'Shea of the vocabulary used by thirteen persons in family and social correspondence, including a total of 5,200 different words. Most of these words occurred a number of times. It will be seen, therefore, that the 1000 words in the Ayres scale are those that were found most frequently in approximately 200,000 words of personal letters, business letters, newspapers, the Bible, and various English authors.

Accepting this list of 1000 words as the most common in the English language, it would appear that by counting the frequency with which the various letters of the alphabet appear in these words, we should secure a very close approximation to their frequency in the English language in general, and in the work done on typewriters in particular.

Table No. I shows in the first column the gross number of occurrences of each letter of the alphabet in the 1000 commonest words. A total of 5433 letters were found. The average length of the words, therefore, is 5.433 letters. By multiplying the number of occurrences of each letter by 1.362 we secure the second column of the table, in which "e" is raised to 1000. The third column shows the percentage of English writing that is made up by each letter of the alphabet. The fourth column gives the frequency of the letters with reference to "q" as one. From this column it will be noted that "e" is used 245 times as often as "q".

Although the evidence thus secured for the frequencies of letters seemed almost conclusive, it was nevertheless thought desirable to support it, if possible by corroborative evidence from original studies. With this purpose in view, three studies were made on the frequencies of letters and punctuation marks in (1) the Gospel of St. Mark, (2) representative business letters, and (3) current newspaper editorials.

TABLE 1.
FREQUENCY OF USE OF LETTERS IN

THE WORDS OF THE ARMY'S SPELLING SCALE

	<u>Times Used</u>	<u>Raised to 1000</u>	<u>Percentage</u>	<u>Based on "Q"</u>
E	774	1000	13.51	245
T	440	609	8.09	147
R	434	591	7.98	145
A	419	571	7.71	139
O	385	524	7.08	128
N	373	508	6.88	124
I	366	598	6.73	122
S	308	420	5.66	103
L	254	350	4.67	85
C	219	298	4.03	73
D	193	263	3.51	64
U	171	233	3.14	57
H	170	232	3.12	56
P	161	219	2.96	54
M	154	210	2.81	51
G	114	155	2.09	38
F	113	154	2.07	37
Y	107	145	1.96	36
B	97	132	1.78	32
W	90	123	1.65	30
V	60	82	1.09	20
K	36	49	.66	12
J	14	19	.25	5
X	13	18	.23	4
Z	5	7	.09	2
Q	<u>3</u>	<u>4</u>	<u>.05</u>	<u>1</u>
Total	5433	7415	100.0%	1790

Table II shows the frequencies of use of letters and punctuation marks in the sixteenth chapter of Mark's Gospel. The first column shows the actual occurrences of letters, while the second column shows the same data with "e" raised to 1000 for purposes of comparison. This was done by multiplying the first column through by 3.69.

Table III shows the frequencies of use of letters and punctuation marks in actual business letters. The first column, again, shows the original data secured by count, while the second column shows the same data with "e" raised to 1000 by multiplying through by 3.82.

Table IV shows the frequencies of use of letters and punctuation marks in a newspaper editorial both in the original form as counted and also as these data appear when raised to the basis of 1000 for "e" by multiplying by 3.97.

A comparison of the data of these three original studies with Table No. I, which gives the frequency of letters in the Ayres Spelling Scale, will reveal much similarity both in the order or rank of the letters and in the relative frequencies of each letter in the four tables. It may justly be said that the differences in the four tables are less noticeable than the similarities. This fact may be given more definite and exact expression statistically. Reference to Table V will show that the frequencies of letters in the Ayres Scale correlate



TABLE 17.
FREQUENCY OF USE OF LETTERS AND PUNCTUATION MARKS
IN THE SIXTIETH CHAPTER OF MARK'S GOSPEL

	<u>Times Used</u>	<u>Raised to 1000</u>
E	271	1000
T	164	605
A	155	572
N	133	565
S	100	391
D	92	340
O	92	340
I	88	325
R	87	321
L	67	247
Y	63	232
U	52	192
C	41	151
V	37	137
W	37	137
P	25	92
C	23	85
F	23	85
B	20	74
G	13	48
V	12	44
K	6	22
Z	3	11
J	2	7
Q	1	4
X	0	0
.	19	70
,	34	125
:	6	22
;	11	41

TABLE 101.
FREQUENCY OF USE OF LETTERS AND PUNCTUATION MARKS
IN BUSINESS LETTERS

	<u>Times Used</u>	<u>Raised to 1000</u>
E	354	1000
A	252	720
O	249	711
T	240	686
N	195	557
S	162	463
I	156	446
L	147	420
H	144	411
R	136	386
D	96	274
C	93	265
U	90	260
M	75	214
Y	72	205
B	51	146
W	48	137
P	33	94
G	30	86
V	24	69
F	18	51
K	12	34
X	9	25
J	6	17
Q	3	8
Z	3	8
,	44	124
:	49	140
;	4	12
.	0	0

TABLE V.
FREQUENCY OF USE OF LETTERS AND PUNCTUATION MARKS
IN A NEWSPAPER EDITORIAL

	<u>Times Used</u>	<u>Raised to 1000</u>
E	252	1000
A	219	876
T	210	841
S	180	723
O	171	685
I	166	673
R	117	468
N	105	420
H	102	409
L	99	396
B	72	289
C	69	276
U	66	263
P	57	228
M	54	216
D	42	169
Y	39	157
W	33	132
F	30	120
G	27	109
V	18	71
K	15	60
J	12	49
X	9	37
Q	6	24
Z	3	11
.	16	64
:	20	81
;	3	0
!	2	7

TABLE V.

CORRELATION OF THE FREQUENCY OF USE OF LETTERS IN THE
1000 WORDS OF THE AYRES SPELLING SCALE WITH THEIR USE
IN TABLES II, III, AND IV.

	Ayres Scale	Average of three tables	Devia- tions of x.	Devia- tions of y.	x^2	y^2	xy
E	1000	1000	715	713	511,225	508,369	509,795
T	309	711	324	124	104,976	153,776	137,576
A	571	723	386	136	81,796	190,096	134,696
O	521	574	229	227	52,451	82,369	35,723
S	420	309	135	232	18,225	49,264	29,970
I	492	480	213	193	45,369	37,249	41,109
N	503	456	223	169	49,529	28,561	37,687
R	591	367	306	80	93,636	6,400	24,480
H	233	156	153	171	2,809	29,341	9,063
L	350	349	65	62	4,225	3,844	4,030
D	263	261	23	26	529	676	572
C	298	209	13	78	169	6,064	1,014
U	233	220	52	67	2,704	4,489	3,484
M	210	194	78	93	5,625	8,649	6,971
Y	146	155	139	102	19,321	10,404	14,170
B	133	170	153	117	23,409	13,689	17,901
P	219	138	66	149	4,356	22,201	9,834
V	123	135	123	132	15,129	17,424	14,321
F	154	85	131	202	17,161	40,804	26,462
G	153	81	130	203	16,900	41,209	26,750
W	82	61	203	223	41,209	51,076	45,876
K	49	39	236	248	55,696	61,804	56,548
J	19	22	256	265	70,756	70,225	70,490
X	18	18	267	269	71,589	72,361	71,823
Q	4	12	261	275	78,121	75,625	37,375
Z	3	9	276	275	77,284	75,625	37,384
Av.	265	267			1,476,109	1,693,780	1,493,833

$$r = \frac{\sum x \cdot y}{\sqrt{\sum x^2 \cdot \sum y^2}} = \frac{1,493,833}{\sqrt{1,476,109 \cdot 1,693,780}} = \frac{1,493,833}{1,581,202} = .946$$

with the frequencies found by averaging the three original studies (Tables II, III, and IV) almost perfectly. The coefficient of correlation is .946 and the Probable Error is .012. The Product-moment formula was used in securing this correlation.

It is of course possible that in any one study of the frequency of letters the chance presence or absence of a few words containing the less common letters, such as K, J, Q, X, or Z, may appreciably influence the result. This difficulty may be obviated by combining the four studies (Tables I, II, III and IV), to which procedure no objection may be raised in view of the very high correlation which obtains, as set forth above.

Table VI shows the frequencies of letters and marks in the four studies made, all raised to the basis of 1000 for "c", while in the fifth column of the table we have the average of the first four. This column is based on the counting of 12,130 letters of the alphabet in connection with the four studies. It is the findings set forth in this fifth column which are accepted in this paper as a basis for evaluating the various letters and marks and their importance or frequency in typewriting.

Diagram I shows graphically the frequencies of the various letters. The fact is that the first six letters (E, T, A, O, S, I) are used more frequently than the

DIAGRAM I.

*Graph Showing Frequency of use
of Letters. See Table .*

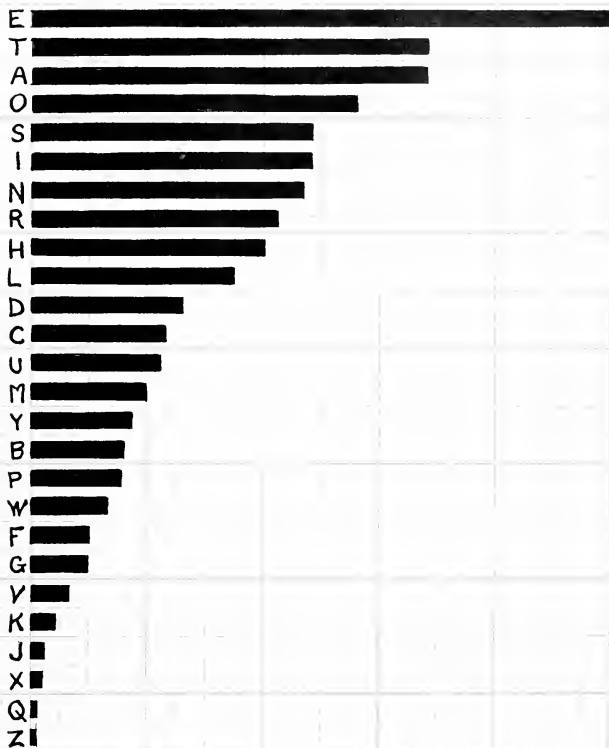


TABLE VI

STUDIES ON THE FREQUENCY OF USE OF

LETTERS AND PUNCTUATION MARKS

	<u>Aves</u>	<u>Mark</u>	<u>No. Letters</u>	<u>Sum Id.</u>	<u>Average</u>
E	1000	1000	1000	1000	1000
T	609	605	686	841	665
A	571	572	720	876	684
O	524	325	711	625	561
S	420	340	463	723	486
I	498	321	446	573	484
N	508	391	557	420	469
F	591	247	383	468	423
H	232	565	411	409	402
L	350	232	420	396	349
D	265	340	274	169	261
C	298	85	265	276	231
U	223	137	260	263	223
M	210	151	214	216	198
Y	146	192	205	157	175
T	132	74	146	289	160
P	219	92	94	228	156
W	123	137	137	132	132
F	154	85	51	120	102
G	155	48	86	109	99
V	82	44	69	71	66
K	49	22	34	60	41
J	19	7	17	49	23
X	18	0	25	37	20
Q	4	4	8	24	10
Z	7	11	8	11	9
.		70	124	64	86
,		125	140	81	115
:		22	12	0	11
;		41	0	7	16

remaining twenty letters. The most startling observation is the fact that "e" is used more frequently than twelve other letters combined (Y, B, P, W, F, G, V, K, J, X, Q, Z). In view of these facts the conclusion is very evident, viz., that the frequencies of the letters should be taken into consideration in the arrangement of the typewriter keyboard.

In further corroboration of the findings of this paper as to the frequencies of letters and marks, the custom of the printing trade may be adduced. Table VII represents in the first column the number of type of each letter included in a large printer's font. For comparative purposes this is reduced to the basis of 1000 for "E" by dividing through by 12, and the results shown in the second column. Our accepted findings are given in the third column. Even a casual comparison of these data reveals so close an agreement between them that a correlation by statistical methods would be superfluous. It needs however to be borne in mind that the printer's font supplies a somewhat larger number of the less common letters and marks than would be usually found necessary. Furthermore, the fact that in the printer's font four letters (O, S, I, N,) are given the same rank, with 2,000 type each, indicates that we have here only a rough approximation of usage, and that the evidence from the make-up of the font is valuable for our purpose only for corroboration and not for definite evaluation of letters.

TABLE VII.
FREQUENCY OF USE OF LETTERS AND PUNCTUATION MARKS
IN PRINTER'S FONTS AS COMPARED WITH AVERAGES
GIVEN IN TABLE VI PAGE 15.

	<u>Printer's Font</u>	<u>Av. this Study</u>
E	12,000	1000
T	9,000	685
A	8,500	684
O	8,000	667
S	8,000	486
I	8,000	484
N	8,000	489
R	6,200	423
H	6,400	402
L	4,000	549
D	4,400	261
C	3,000	231
U	3,400	223
M	3,000	196
Y	2,000	175
B	1,600	160
P	1,700	158
F	2,000	172
E	2,500	102
G	1,700	99
V	1,200	66
K	800	41
J	400	23
X	400	20
Q	500	10
Z	200	9
<u>In font of 100 "e"</u>		
.	40	86
,	40	115
:	5	11
;	5	16

II. ERRORS IN TYPEWRITING AND THEIR CAUSES.

For the purposes of this part of our investigation about 500 full size pages of practice typewriting work were secured, from approximately 100 different individuals, and the errors found therein counted and tabulated up to the point where "E" was charged with 1000 errors. This point was reached when all but three of the pages had been checked. The errors for the several letters are given in Table VIII, and for convenience of comparison our adopted scale of frequencies of use is given therewith. The percentage relationship between these two series of data is given in the third column of Table VIII, from which it will be seen that twelve letters are as good or better than "E" from the standpoint of accuracy, while thirteen rank below "E". The median is 108.3. The close parallelism between accuracy and use may be seen from the fact that the average frequency is 287 per letter, and the average errors recorded, 292 per letter, a very small difference indeed.

In Table IX this relationship between accuracy and frequency of use is still more definitely calculated by the use of the product-moment formula. The coefficient of correlation is found to be .924 with a P. E. of .021. This shows a very close relationship between use and accuracy and bears out the adage, "Practice makes perfect."

TABLE VIII.
 ERRORS MADE IN ACTUAL TYPEWRITING AS COMPARED
 WITH FREQUENCY OF OCCURRENCE OF LETTERS

	<u>Frequency</u>	<u>Errors</u>	<u>Percentage</u>
E	1000	1000	100.
T	665	636	92.8
A	684	596	87.1
O	561	462	82.4
S	486	395	81.3
I	484	378	78.1
N	469	372	79.3
R	423	440	104.
H	402	223	55.5
L	349	339	97.1
D	261	418	160.1
C	271	283	123.5
U	223	224	100.
M	198	321	162.1
Y	175	246	140.6
B	160	97	60.6
P	158	73	46.2
W	132	84	63.6
F	102	209	204.9
G	99	325	328.2
V	66	158	239.4
K	41	96	234.1
J	23	26	117.
X	20	140	700.
Q	10	32	320.
Z	9	20	222.2

Mod. 108.3

Av. 156.7

TABLE IV.
CORRELATION OF FREQUENCY OF USE OF LETTERS WITH ERRORS
MADE IN ACTUAL TYPEWRITING.

	<u>Use</u>	<u>Errors</u>	<u>Dev. x</u>	<u>Dev. y</u>	<u>x²</u>	<u>y²</u>	<u>xy</u>
E	1000	1000	+ 713	+808	508,369	652,664	576,104
T	685	636	+398	+344	158,404	118,336	136,912
A	684	596	+397	+304	147,709	92,416	120,688
C	561	462	+274	+170	75,076	28,900	46,580
S	486	396	+138	+102	39,601	10,609	20,497
I	484	378	+197	+ 86	38,809	7,396	16,942
N	462	372	+182	+ 82	33,124	6,724	14,924
R	435	440	+130	+148	16,496	21,904	20,128
H	402	323	+115	- 69	13,225	4,761	- 7,935
L	349	339	+ 62	+ 47	3,844	2,209	2,914
D	361	416	-26	+126	676	15,876	- 3,276
O	231	283	-56	- 9	3,136	81	264
U	223	224	-64	- 68	4,096	4,624	4,352
M	198	321	-89	+ 29	7,921	841	- 2,581
Y	175	246	-112	- 46	12,544	2,116	5,152
B	160	97	-127	-193	16,129	37,225	24,765
P	156	73	-129	-219	16,641	47,961	26,251
W	172	84	-165	-208	24,025	43,264	23,240
F	102	209	-185	- 83	34,225	6,889	15,355
G	99	325	-188	+ 33	35,344	1,089	- 6,204
V	66	158	-221	-154	48,841	17,956	29,614
K	41	96	-246	-196	60,516	38,416	48,216
J	23	26	-264	-266	69,696	70,756	70,224
X	20	140	-267	-152	71,289	23,104	40,584
Q	10	32	-277	-260	76,729	67,600	72,020
Z	9	20	-278	-272	77,284	73,984	73,616

Av. 287 282 cr Totals 1,595,749 1,598,701 1,580,586

$$r = \frac{\sum x \cdot y}{\sqrt{\sum x^2 \cdot \sum y^2}} = \frac{1,380,586}{\sqrt{1,595,749 \times 1,392,701}} = \frac{1,380,586}{1,498,979} = .924$$

This relationship is set forth in a more graphical way in Table X. In the upper half of that table we have the thirteen most used letters, in the lower half the thirteen least frequent letters. In the first column the frequency of use of letters is indicated by the use of a plus sign for those letters above the median in use, and a minus sign for those below the median. In the second column a plus sign indicates those letters above the median in number of errors, and a minus sign those below the median in number of errors. There are only two of the thirteen most common letters which are below the median in number of errors, and then by a very narrow margin. Also only two of the thirteen least used letters are above the median in number of errors, nor then by very large margins. In the third column the plus sign indicates those letters which are above the median in percentage of accuracy, while the minus sign indicates those letters which are below the median in accuracy. With five exceptions out of the 26 letters, frequency of use and better than median accuracy go together, or infrequency of use with inaccuracy. One of the five exceptions is by a negligible difference.

We had expected to find that some keys or rows of keys on the typewriter would be more accurate than others. The findings in Tables IV and X contradict this expecta-

TABLE X.
COMPARISON OF FREQUENCY OF USE OF LETTERS WITH ACCURACY

	Above Md. in frequency of use + , below -.	Above Md. in number of errors +, below -.	Above Md. in accuracy + , below -.
E	+	+	+
T	+	+	+
A	+	+	+
O	+	+	+
S	+	+	+
I	+	+	+
N	+	+	+
R	+	+	+
H	+	-#	+
L	+	+	+
D	+	+	-
C	+	+	-#
U	+	-#	+
<hr/>			
K	-	+	-
Y	-	-	-
B	-	-	+
P	-	-	+
V	-	-	+
F	-	-	-
G	-	+	-
J	-	-	-
X	-	-	-
Q	-	-	-
Z	-	-	-

The exceptions noted are very near the medians.

tion, and indicate that the position of keys on the present keyboard exercises very little if any measurable effect on accuracy. It has not been found possible to say with any degree of assurance that any one position on the keyboard is better than any other from the standpoint of accuracy.

The question may still be raised whether the errors made in typing any letter occur in combination with any other letter or letters. To answer this question errors were tabulated until 100 had been noted for "E", and in each case the letter after which the error occurred was noted. The results of this study are set forth in Table VI. This table should be read as follows: of the 100 errors made in writing "E", 26 occurred after W, 14 after L, 12 after H, 12 after N, 6 after T, 6 after S, 5 after V, 5 after R, 5 after Z, 3 after K, 3 after F, 3 after D, 2 after O, and 2 after G. It does not appear from a study of this table that there is any connection between accuracy and the combination of letters with which any one letter may happen to be written. This serves only to throw the back upon our conclusion that accuracy or inaccuracy were the results of frequent or infrequent practice, due to frequent or infrequent use of the letter.

TABLE III.

ERRORS AFTER THE LETTERS APPEARING MOST FREQUENTLY

E	W20, L14, R12, W12, S6, T6, W6, M6, T6, A6, E6, T6, O1.
T	O10, A9, I8, S6, M4, O1, E6, T6, T6, W6, O6.
R	E13, O10, A10, M4, E6, P6.
A	E10, T10, O4, W4, E3, P6, P6, O2, E2, W2, O1, M1.
S	E10, A10, I4, P1, T6, T2, I2, W2, T2.
W	E6, I6, O4, R4, T2, I2.
O	J8, E6, I6, P4, T4, T2, I2, O3, E6, W1.
H	E6, I6, P4, W6, T2, T2, E2, E6, A6, M1.
D	E10, O6, M1, E6, I2, M1.
I	E6, P6, E6, W6, T2, A6, I6, O6, E1, D1.
E	M11, E4, A4, I1, M1, O1.
M	W6, P6, O4, T1, O2, A1.
H	O6, I4, J6, I2, L2, T2, O1.
U	O6, I4, J6, Y6, O2, O6, E1.
Y	A6, M1, T6, I2, I2, I2, W2, T1.
G	L6, A4, I2, W6, S2, M1.
V	A6, I4, O4, M1, T2, M1.
W	A2, E1.
E	A6, I2, O2, M1.
T	E2, I2, T2, O1, M1.
L	O1, P6, I2, M1, A1.
P	E6, I2, O1, E1.
X	A2, O2, I2, E1.
G	E1.
Q	A2.
Z	O2, A1.

Tabulating from the above the errors made after each of the letters, we get the following: after E 81 errors, A 61, O 16, T 16, R 45, I 34, H 32, L 31, V 30, T 30, S 26, U 22, P 18, B 16, W 14, F 11, C 11, D 11, V 10, Y 7, G 7, K 6, Z 5, J 0, Q 0, X 0. Inspection shows that this correlates very highly with the frequency of use of letters, which would indicate merely that most errors happen after the letters most frequently used because most trials occur, and therefore most chance for error after the frequently used letters.

III. RELATIVE ABILITIES OF THE EIGHT FINGERS AND THE TWO HANDS FOR TYPING.

For the purpose of determining the relative abilities of the eight fingers and the two hands three studies were made. The first of these studies was made upon 50 High School girls; the second on 46 High School boys. In these two studies the following method was used. The subjects were instructed to hold the thumb of the right hand against the center of the typewriter frame, in front of the space bar, and to tap the letter "J" with the first finger of the right hand as rapidly as possible. Thirty seconds were allowed. Then with the thumb of the left hand in the same position, the subject tapped the letter "F" for thirty seconds. Then in the same way, with the right hand second finger "K", left hand second finger "d", right hand third finger "L", left hand third finger "S", right hand fourth finger ";", left hand fourth finger "A", each for thirty seconds. The experimenter counted the number of taps as they left their impressions on typewriter paper in the regular way, by each of the eight fingers of the 96 subjects.

The purpose of holding the thumb against the metal frame of the typewriter was to eliminate as much as possible, wrist and arm movement, for it was desired to test only finger abilities. It was found that by holding

the thumb in this position the subject was compelled to make the taps by relying upon the fingers alone, as was desired for the purposes of the experiment. The results of these two studies are set forth in Tables XII and XIII.

An inspection of the medians in these two tables will show that the eight fingers have about the same rank and relative ability for the two sexes. The only noticeable sex difference is in speed of tapping, with respect to which the boys excelled the girls by 24.6 per cent.

The third study was made of 42 college girls and 12 teachers of Frederick County, Maryland. In this study a somewhat different method was pursued. The subjects were required to tap for one minute with a pencil with the right hand, then one minute with the left hand. The marks were subsequently counted to get the scores. (A later study showed that when the subjects attempted to count their taps as they went, their speed was impeded. A few reported that this served to increase their scores.) The subjects were further required to tap for thirty seconds upon their desks with each finger. Particular instructions were given as to the position to be assumed: with the wrist resting upon the desk (to prevent wrist movement in tapping) and with three fingers also resting with their tips upon the desk. It was found

TABLE XII.

TAPPING TESTS ON TYPING MACHINES—HIGH SCHOOL GIRLS

No.	Left Hand				Right Hand			
	4	3	2	1	1	2	3	4
	a	s	d	f	j	k	l	;
1	112	117	120	125	131	136	143	146
2	122	124	128	150	117	143	143	143
3	89	103	100	96	96	107	112	109
4	130	129	139	138	122	139	143	139
5	131	124	93	148	112	143	133	117
6	103	125	74	135	122	136	131	108
7	121	141	113	150	158	137	144	112
8	72	63	73	64	60	64	68	69
9	115	128	109	78	151	154	172	140
10	84	92	93	150	98	113	120	94
11	76	90	101	77	82	137	113	100
12	99	128	128	120	119	146	151	132
13	118	122	150	140	106	137	115	120
14	105	120	129	123	137	154	163	152
15	90	106	77	123	122	128	113	102
16	93	95	131	140	140	138	112	101
17	74	74	77	77	73	75	76	76
18	119	140	109	120	131	148	150	139
19	85	126	113	146	155	141	152	91
20	117	120	119	144	154	139	126	134
21	109	118	106	123	113	119	124	121
22	91	117	95	128	103	139	144	121
23	138	131	149	131	159	151	161	153
24	76	117	99	113	101	116	81	80
25	103	110	107	121	89	114	127	98
26	88	100	115	103	108	109	96	90
27	93	102	111	110	107	112	107	114
28	105	143	144	137	147	141	166	156
29	101	117	136	114	122	147	154	132
30	97	117	120	90	116	128	134	119
31	70	92	106	87	107	105	93	75
32	81	101	104	103	101	126	112	103
33	100	119	111	100	109	116	122	99
34	112	122	123	108	141	135	135	146
35	83	122	122	88	117	127	151	128
36	84	94	94	95	84	87	114	110
37	99	120	154	124	129	145	130	154
38	113	122	128	120	135	140	145	149
39	114	104	114	84	81	113	98	106
40	110	125	77	111	126	112	144	118

TABLE XII (continued)

41.	96	104	27	92	99	99	119	112
42	116	120	128	121	120	124	124	125
43	107	121	123	111	112	118	126	127
44	107	108	112	90	140	117	105	124
45	120	122	127	109	121	128	124	127
46	108	118	121	102	119	122	122	127
47	111	127	126	127	121	106	94	92
48	112	109	101	96	100	97	121	124
49	106	109	117	105	120	118	106	100
50	121	110	120	111	125	124	116	110
Av.	107	116	113	115	116	126	126	119
sd.	106	119	117	119	119	120	123	117

TABLE XIII.

TAPPING TEST ON TRIPLES — 1000 CYCLES PER MIN.

No.	Left Hand				Right Hand			
	1	2	3	4	1	2	3	4
1	157	139	124	131	156	127	120	132
2	134	142	160	184	205	217	203	182
3	149	154	134	163	150	160	151	179
4	105	108	117	123	141	149	135	98
5	150	152	182	154	154	151	164	160
6	153	150	167	145	177	180	183	173
7	123	138	143	123	166	161	130	139
8	129	158	163	175	165	153	133	151
9	137	130	193	161	156	157	222	167
10	129	121	151	135	163	166	162	154
11	132	143	136	140	139	152	162	154
12	139	140	141	155	159	146	150	136
13	103	126	126	121	178	201	205	183
14	126	172	155	148	181	182	189	167
15	94	79	96	94	88	139	126	119
16	150	146	153	157	179	161	190	149
17	93	115	136	159	179	176	178	137
18	181	186	186	176	181	204	202	181
19	134	138	158	166	172	206	211	195
20	112	143	126	144	141	145	166	124
21	129	129	143	145	158	164	161	169
22	112	123	131	122	137	195	178	153
23	124	117	124	132	166	130	137	147
24	139	131	141	138	157	157	173	169
25	100	122	139	142	153	168	180	121
26	121	134	151	147	130	163	156	134
27	148	139	142	165	150	169	158	145
28	90	101	120	108	125	141	142	119
29	123	110	128	133	120	143	133	156
30	126	131	127	151	154	174	160	171
31	114	126	142	142	165	187	172	153
32	119	129	143	139	140	173	160	150
33	105	118	155	145	172	196	185	171
34	109	99	115	114	132	132	154	137
35	134	139	169	145	130	169	132	140
36	113	104	122	114	151	140	136	123
37	121	122	139	136	137	165	161	140
38	137	135	149	141	135	178	146	134
39	129	138	144	143	132	143	144	144
40	151	154	157	151	151	166	169	150
41	142	149	169	162	142	140	102	201
42	140	151	168	156	165	166	169	140
43	118	116	125	121	145	156	147	157
44	159	156	176	163	199	212	202	175
45	124	139	141	149	154	146	145	136
46	150	129	145	151	156	155	154	150
Av.	128	134	141	143	136	167	164	146
Std.	127	134	145	145	153	166	164	151

that this position effectually prevented any wrist or arm movement being used and secured records of the tapping abilities of the fingers alone.

An inspection of the medians for the eight fingers in Table XIV shows that they very closely bear out the results of the first and second studies as shown in Tables XII and XIII. The three studies involve a total of 190,410 taps, made by 150 different individuals. It is believed that by combining these three studies by the method of averages, we may secure conclusions as to the relative abilities of the fingers and hands which may be relied upon.

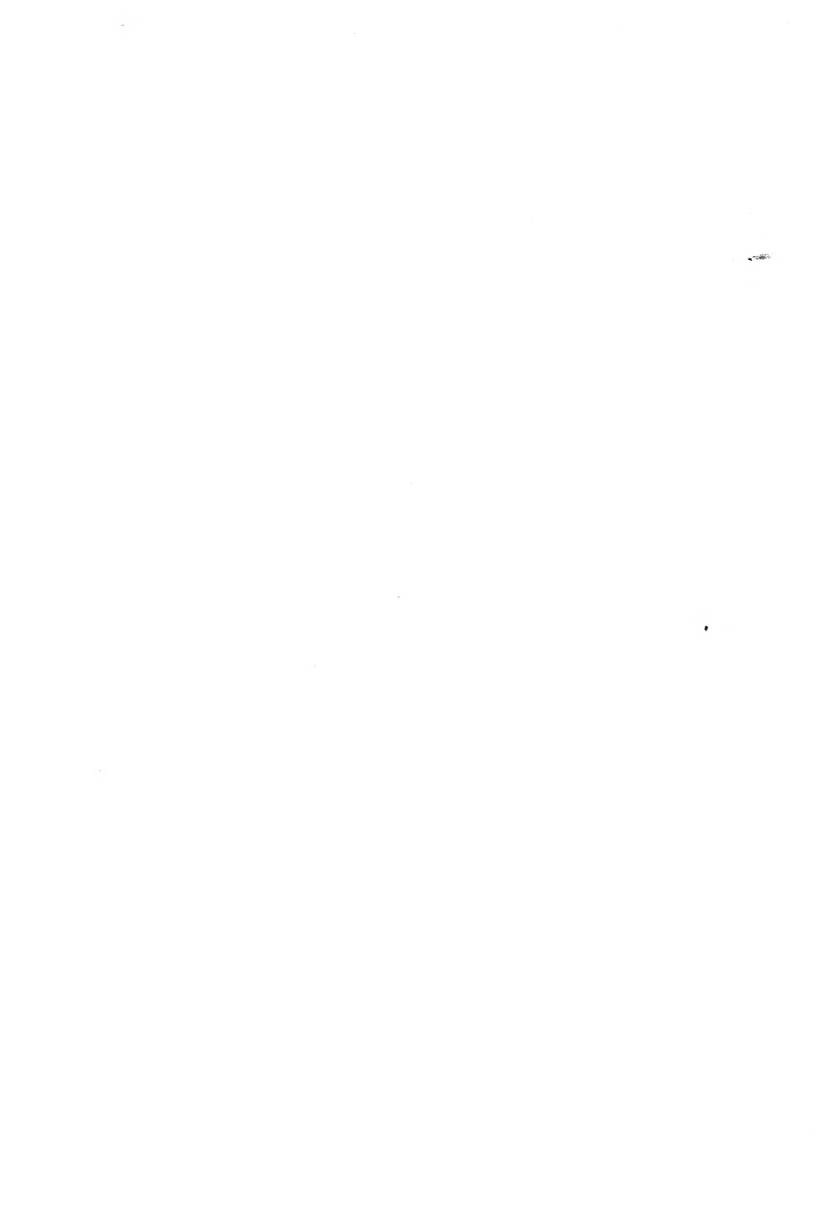


TABLE XIV (continued).

No.	R.	I.	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
47	360	340	189	145	98	82	105	100	110	92		
48	400	340	192	147	107	108	10	73	103	171		
49	404	340	194	151	117	119	82	104	110	100		
50	408	340	178	139	110	120	103	100	119	10		
51	414	344	150	118	100	103	108	91	113	10		
52	414	344	149	111	101	108	100	110	100	110		
53	408	398	131	94	93	95	10	91	70	98		
54	412	324	110	110	98	78	59	80	85	92		
Av.	363	110	181	143	104	111	105	79	103	103		
d.	366	311	140	118	103	101	103	117	107			

IV. THE FINGER AND HAND LOADS OF THE PRESENT TYPEWRITER KEYBOARD.

Now that we are prepared to state in a mathematical form the relative abilities of the two hands and the fingers, it would seem worth while first to raise the question, what is being expected of the fingers and hands by the present typewriter keyboard. We are assuming, of course, that the typewriter is to be used by a touch operator. Probably very few persons are any longer disposed to dispute the great advantage of the "touch" method for speed and accuracy. Its advantage from the standpoint of fatigue is still greater.

In accordance with the touch method each of the eight fingers has its own proper keys, three for each finger except the first finger of each hand which has six. Table XV gives for each finger the letters it strikes and their values, and the sum of these, which is the finger load. These letter values are taken from Table VI. Denoting the fingers of the right hand as R1, R2, R3, and R4, and those of the left hand as L1, L2, L3, and L4, we find their loads to be, in the same order: R1 1490, R2 810, R3 908, R4 296, L1 1338, L2 1498, L3 656, L4 803. Adding these finger loads for each hand we get the hand loads: for the right hand 3404, for the left 4488. In view of the fact that in Tables VII, VIII, and XIV we found finger abilities to be not very dissimilar, it is

TABLE XV.
THE THREFTWITING LOAD OF THE RIGHT FINGERS AND THE
RIGHT AND LEFT HANDS

<u>Right Hand</u>				
<u>Fingers</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
y	175	i 484	o 551	p 158
h	402	k 41	l 349	: 16
n	469	, 115	. 86	: 11
u	223			? 11
j	23			Shift 100
m	198			
	1190	540	996	296

Total for the right hand: 3422

<u>Left Hand</u>				
<u>Fingers</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
r	423	e 1000	w 152	q 10
f	102	d 261	s 486	a 684
v	66	c 231	x 20	z 9
t	685			Shift 100
g	99			
b	160			
	1535	1492	656	803

Total for the left hand: 4466

rather than finding to find that R1, R2, and R3 are on the present typewriter keyboard given more than five times as much work to do as is given to R4. In view, also, of the generally known fact that the index of right-handedness may be roughly expressed by the ratio of ten to nine, that is, that the ability of the right hand is approximately one-ninth greater than that of the left, it is surprising to find that the present keyboard gives the heavier load to the weaker member.

The question may be raised: why are 100 strikes recorded for both the right and left shift key? The total of 200 were secured by actual count. However, whether either hand will strike exactly half of them will vary somewhat with context. When a letter on the left of the keyboard is to be capitalized, the right shift key must be struck and vice versa. Inasmuch as the most used letters are on the left side of the keyboard it is very probable that the right shift key is the more frequently used. However, the total number will remain the same and an equal division of the total 200, while not entirely exact, is as near as can be gotten. On the revised keyboard, with the letters distributed according to finger and hand ability and frequency of use of letters, the right and left shift key will be struck more nearly equally.

V. THE CONSIDERATIONS TO BE TAKEN INTO ACCOUNT
IN THE ARRANGEMENT OF A SCIENTIFIC KEYBOARD,
AND A SUGGESTION FOR SUCH KEYBOARD.

The several considerations which should be borne in mind by one who is attempting to make a scientific rearrangement of the typewriter keyboard are the following:

1. The measured abilities of the right fingers and of the right as compared with the left hand, should be taken into consideration, and loads assigned in proportion to strength.

2. The measured frequency of use of the letters of the alphabet and punctuation marks must be made the basis for calculating the loads to be assigned to the several fingers.

3. In addition to the above there are certain pedagogical considerations:

a. Most used letters, for home or guide keys, since on a keyboard so arranged the work could be done with the fewest possible changes of position of hands. Also the frequent use of these letters will aid the pupil in the early fixing of these home-key positions.

b. The next most used letters should be assigned to those keys or positions which appear to be the favorable ones from the standpoint of accuracy.

c. Since beginners find it easier to use the first fingers than the other fingers, and since the approved

method of teaching type-writing, as well as other subjects, is that of proceeding from the easy to the more difficult, it is desirable to so arrange the keyboard, by assigning several of the vowels to the first fingers, that simple practice words and sentences may be written by the beginner, even in the earliest stages of the learning process.

For purposes of the first consideration, Table XVI assembles the data from Tables XII, XIII, and XIV, i.e., the median tapping abilities of the eight fingers of High School girls, High School boys, and College girls and teachers, combining the three by the method of averages. Table XVI also includes the present keyboard load from Table XV. Dividing the total keyboard load (7910) by the sum of the finger abilities (1046) we find that each point of finger ability must be multiplied by 7.56 so as to reapportion the whole load upon the fingers in proportion with their abilities. Comparing the ideal finger-loads with the present finger-loads, we find four over-loads of 49.8, 53., 35.6, and .5 ; also four under-loads, 6.1, 26.9, 41.6, and 89.4.

Of the 290,410 taps made in this study, 100,617 were made by the right hand, and 89,593 by the left in equal numbers of seconds. The ratio of the ability of the right hand to that of the left is as 100 to 88.87,

TABLE XVI.
COMPARISON OF FINGER AND HAND AVERAGE IDEAL WITH IDEAL
LOADS OF THE FINGERS AND HANDS

	LEFT				RIGHT			
	4	3	2	1	1	2	3	4
Ide. for H. S. Girls	100	117	117	117	119	130	138	117
Ide. for V. S. Boys	127	131	145	145	168	163	164	151
Ide. College Girls and teachers	107	103	125	145	100	138	101	117
Averages	113	119	139	136	115	145	131	128

Multiplying these avs.

by 7.55 to get ideal

typewriting loads: 855 900 975 1038 1097 1096 991 968

The loads on the
present keyboard are 803 658 1192 1535 1490 640 996 296

Percentage of over-)
or under-load of the) -25.9 +49.3 -41.6 -69.4
fingers on present)
typewriter keyboard) -6.1 +53. +35.8 +5

HANDS

	<u>Right</u>	<u>Left</u>
Tapping ability:)	100,517 taps	89,593 taps
(193,410 taps by)		
150 individuals))	Ratio: 100 to	88.87
Present load)	3423 taps	4488 taps
)	Ratio: 100 to	131.25
Per cent of over-)		47.7
or under-load)		(over-load of left hand.)

or approximately as ten is to nine. This agrees with the findings of Tryan.¹ The present right and left hand loads in tapping are 64.8 taps for the right to 44.6 for the left, or a ratio of ten to 59.33. These data show an overload of the left hand of 47.7 per cent as compared with the right hand, on the present typewriter keyboard. The over-loads and under-loads discovered are more graphically shown in Diagram II.

The critic's objection is advanced that in comparing the measures of the tapping abilities of the several fingers as obtained on the typewriter, with those obtained in tapping on desks, two different, and for all we know, heterogeneous sets of data are being added together. In reply to this suggestion the following considerations are advanced and need to be taken into account.

First, it should be borne in mind that the same purpose was apparent in these two series of experimentation, namely, the attempt to get a mathematical statement of the comparative abilities of the several fingers. The two experiments are alike in that both attempt to

1. TRYAN, American Journal of Psychology, 1892, V, 123-204.

to secure a record in terms of the number of taps each finger can make in the same period of thirty seconds or one minute.

Second, it is true that tapping on a desk is not, so far as we know, the same thing as tapping the keys of a typewriter in the ordinary way of that machine. But it is also true that tapping the keys of a typewriter under the controlled situation, namely, with the thumb touching the frame of the machine, beneath the space bar, may, for all we know, be no more like the process of actual typewriting than is tapping on a desk as described above. In fact, it may be that the former more nearly approximates the actual process involved in typewriting than does the latter. Both are controlled situations, with the purpose of preventing an undue influence upon the outcome as a result of leaving the arm and wrist free to do the tapping, instead of compelling the fingers to do it.

Third, of the three sets of data which are contained in Table XVI, the third (the results of tapping on desks) does not differ more from either the first (the results for H. S. Girls for taps on typewriters) or the second (the results for H. S. Boys tapping on typewriters) than the first differs from the second. Therefore, an argument against including the third, because differing from the first and second, would be just as good an argument, so far as it goes, for excluding either the first or second because it differs from the other.

Fourth, the average scores for the fingers secured by combining the three sets of data in Table XVI differ from the scores which would have been secured by combining only the two first sets of data of that table by only a little over four per cent. So far as the relative abilities of the two hands are concerned, the three sets of data agree, all giving the ratio of approximately ten to nine. This larger result is therefore unaffected by the inclusion or exclusion of the third set of data. A study of the suggested keyboard in Diagram III will reveal the fact that it was found impossible so to assign loads as to give each finger exactly the proper amount of work. In the case of the third finger of the left hand the error amounts to as much as one and one-third per cent. In view of this fact the above mentioned difference of four per cent loses much of its significance.

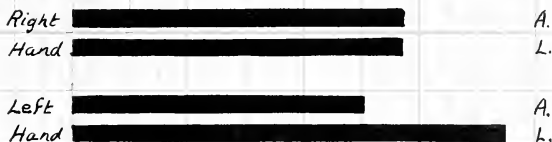
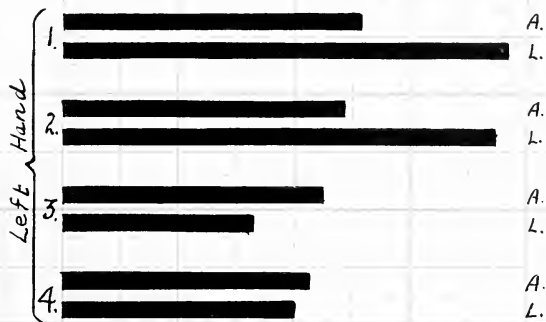
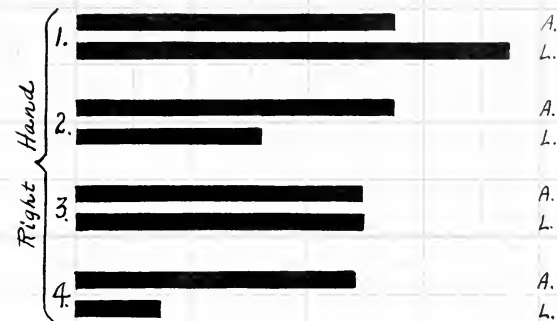
Fifth, the fact is generally known, especially among pianists and typists, that the third finger is the least capable. This fact is not so clearly revealed in the first two sets of data of Table XVI as in the third. This may perhaps be explained by saying that the third finger, in the case of the experiment on the typewriter, being further removed from the flexed joint, the thumb, than was the first or second

was perhaps given some little aid in its tapping from the movement of the wrist and arm. Should this explanation be the correct one, it would appear that the third experiment avoided this chance for error, and is to that extent a corrective. It is the opinion of the writer that the inclusion of the third set of data in the averages, gives a truer estimate of the abilities of the fingers than would be the case were these data omitted.

To return to the considerations which must be taken into account in arranging a keyboard along scientific lines, it was noted as one of the pedagogical considerations that the eight most frequently used letters should be assigned to the home keys, so far as this may be found to be possible without overloading of fingers. Also that several of the vowels should be assigned to the first fingers, for the reason stated.

From the consideration of accuracy two results might follow. It might be found that certain vertical rows of keys, that is, certain fingers, were more accurate, or that certain horizontal rows were more accurate than others. These two possibilities are studied in Table XVII. In the upper half of this table accuracy is compared with frequency of use for each of the horizontal rows of keys. In Table IX we saw that with reference to the individual letters, accuracy and frequency of use were almost perfectly correlated. Table XVII, however, seems to show that we have greatest accuracy in the upper

Diagram II.



GRAPHIC REPRESENTATION OF THE FINGER AND HAND ABILITIES AND THEIR LOADS ON THE PRESENT TYPEWRITER. In each case the ability is given first, and marked A,

while the load is denoted by L.

TABLE XVII.
THE ACCURACY OF HORIZONTAL LINES OF KEYS ON TYPEWRITER

<u>Upper Line</u>			<u>Middle Line</u>			<u>Lower Line</u>		
Rank		% of	Rank		% of	Rank		% of
in use		errors	in use		errors	in use		errors
Q 25		320	A 3		87	Z 26		222
W 18		64	S 5		81	X 24		700
E 1		100	D 11		100	C 12		123
R 8		104	F 19		208	V 21		239
T 2		93	G 20		228	B 16		61
Y 15		141	H 9		86	K 7		79
U 13		100	J 23		113	M 14		162
I 6		78	K 22		234			
O 4		82	L 10		97			
P 17		46						
Av. 10.9		112.8	13.6		151.2	17.1		226.7

COMPARISON OF THE RANK OF THE RIGHT FINGERS AND THE RATES
IN ACCURACY AND IN LOAD IN TYPEWRITING

<u>Fingers</u>		<u>Rank in</u>	<u>Rank in</u>
		<u>Accuracy</u>	<u>Load</u>
Right....	(1	3	8
hand	(2	5	2
	(3	2	5
	(4	1	1
Left....	(1	5	3
hand	(2	2 4	7
	(3	1 8	3
	(4	7	4
Right hand		105% of errors.	3422
Left hand		192% " "	4486

horizontal line, with decreasing accuracy in the middle and especially in the lower lines, to an extent that is not justified by use or disuse. Since this is the case it will be well to assign the more frequently used letters, after the home keys have been supplied, to the upper row of keys.

The second part of Table XVII, on the other hand, shows differences in accuracy of fingers, that is, of vertical rows of keys. These data are taken from table eighteen. Not while the accuracy of fingers seems to differ, it appears from the table that this is due to the loads assigned to the fingers and hands, rather than to qualities of the fingers or hands themselves. For when the fingers are given their rank for accuracy and for load, we find a close correlation. The overloaded fingers tend to be inaccurate, while the underloaded fingers tend to be more accurate. In the case of the two hands the evidence is ever more clear. The right hand with small load has high accuracy. The left hand with heavy load has low accuracy score. The average frequency of use of letters written by the left hand on the present keyboard is 291, by the right 280. So far as the law of use goes, the left hand should be four per cent more accurate than the right. Instead of this we find the right hand 84% more accurate than the left. This must be due to the over-load of the left hand.

TABLE XVIII.
THE ACCURACY OF THE EIGHT FINGERS IN TYPEWRITING
(PERCENTAGES)

<u>Right Hand</u>				
<u>Fingers</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
y	141	i 78	o 82	p 46
h	56	k 234	l 97	
n	79	,	.	
u	100			
j	113			
m	168			
<u>Average</u>	<u>108</u>	<u>106</u>	<u>89</u>	<u>46</u>

Average for the right hand: 108

<u>Left Hand</u>				
<u>Fingers</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
r	104	s 100	w 64	q 330
f	205	a 160	s 81	a 87
v	239	c 123	x 700	z 222
t	93			
g	328			
b	61			
<u>Average</u>	<u>172</u>	<u>126</u>	<u>282</u>	<u>210</u>

Average for the left hand: 162

This evidence tends to show that nearly half of the errors made by the left hand in typewriting are unpreventable, due to the bad apportioning of the typewriting load in the present keyboard.

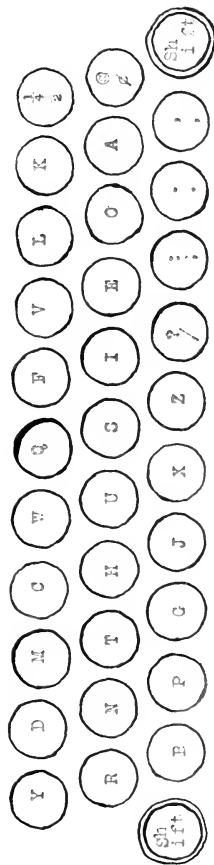
A further important reason why the typewriter keyboard should be scientifically rearranged is the self-evident fact that maximum speed and ease of operation can never be attained so long as some fingers are overworked, while others do not have a chance to contribute their full share to the total result.

A rearrangement of the keyboard will, it is clear, make for improved speed and accuracy in typewriting.

The present arrangement of the typewriter keyboard antedates the "touch" method of operating, which has come to be the only accepted method in the teaching of typewriting. Therefore the considerations, if any, which suggested the present arrangement of the keyboard, do not apply, but new considerations must be brought to bear which take account of the fact that all of the fingers are to be used and should contribute their share, no more and no less.

In accordance with the above considerations we offer herewith a suggested rearrangement of the typewriter keyboard.

DIAGRAM III.



Ideal load 855 900 975 1028 1097 1096 991 980

Load on this keyboard 858 888 922 1031 1098 1093 996 971

Diagram showing suggested rearrangement of the keyboard, the ideal finger loads as given in Table XVI, and the loads this keyboard would assign.

BIBLIOGRAPHY

- Ayres, Measuring Scale for Ability in Spelling
- Ayres, The Spelling Vocabularies of Personal and Business Letters, Russell Sage Foundation, New York, 1912.
- Book, The Psychology of Skill, with special reference to its acquisition in Typewriting. U. of Mont. Pub. Bulletin 53, Psych. Series No. 1.
- Bryan, Am. Journal of Psych. 1892, V, p. 123ff.
- Bryan and Harter, Studies in the Telegraphic Language. Psychological Review, Vol. VI.
- Burk, From Fundamental to Accessory in the Development of the Nervous System and of Movements. Ped. Sem. Vol. VI, pp. 5-64.
- Cook & O'Shea, The Child and his Spelling. Indianapolis '14.
- Eldridge, Six Thousand Common English Words, Niagara Falls, N. Y. 1911.
- Fritz-Eldridge, Expert Typewriting, American Book Co.
- Gordon, Educational Psychology.
- Gould, G. M., Right-handedness and Left-handedness.
- Judd, C. H., The Psychology of the High School Subjects.
- Knowles, Rev. J., The London Point System of Reading for the Blind. London 1904.
- Owen, Margaret, P., The Secret of Typewriting Speed.
- Parker, Methods of Teaching in High Schools.

- Foss, Typewriting Manual, Fowe Pub. Co., Baltimore.
- SoRelle & Cutler, Rational Typewriting.
- SoRelle, Methods of Teaching Typewriting.
- Starch, D., Periods of Work in Learning, Journal of Educational Psychology, vol. 3, pp. 209-213.
- Thorndike, Practice in the Case of Typewriting, Ped. Sem. vol. 20, pp. 516-29.
- Thorndike, Educational Psychology, Briefer Course, pp. 167, 169, 226, 249f, 252.
- Wilson, D., The Right Hand: Left-handedness.
- Washburn, M.F., Movement and Mental Imagery.
- Woodworth, R., Le Mouvement.
- Woodworth, R., Accuracy of Voluntary Movement. Psych. Review Monograph 3.
- Woolley, H.R., The Development of Right-handedness in a Normal Infant. Psych. Rev. 17.

VITA

Roy Edward Hoke, son of Edward John and Mary Margaret Hoke, born at York, Pennsylvania, July 3, 1893. Grammar school education was received in Lancaster, Pa., Lewistown, Pa., and Newark, N. J. College preparatory course was taken in The Boys High School, Lancaster, Pa. Attended Franklin and Marshall College, Lancaster, Pa., 1912 to 1916, receiving the A. B. degree. The A. M. degree was received in the following year, 1917. Was elected a member of the Phi Beta Kappa Society in the Theta Chapter upon graduation in 1916. Taught during the school year 1916-1917 in the Columbia Grammar School, New York City. During the following year attended the Theological Seminary of the Reformed Church in the United States, at Lancaster, Pa. Enlisted in the U. S. Army May 30, 1918, serving as Assistant Chaplain with the rank of Sergeant at Fort Oglethorpe, Ga., receiving honorable discharge January 13, 1919. Attended Johns Hopkins University during the years 1919, 1919-20, 1920-21. Ordained into the Christian Ministry of the Reformed Church August 24, 1919, and installed Pastor of the Reformed Charge, Jefferson, Md. At the University courses were pursued in Education, Psychology, and Philosophy, under the instruction of Prof. Edward F. Buchner, Prof. Knight Dunlap, Prof. A. O. Lovejoy, Dr. David F. Weglein, Dr. Henry Slonimsky, and Miss Florence E. Damberger, to each of whom the writer is indebted, and hereby expresses his appreciation.





